

REMARKS

Claims 1-40 remain in the application. Independent Claims 1 and 21 are amended to emphasize distinctions over cited art. Specifically, the three possible mechanisms of electric field induced band gap change ((1) molecular conformation change or an isomerization; (2) change of extended conjugation via chemical bonding change to change the band gap; or (3) molecular folding or stretching) are reintroduced into the claims.

Claims 1-3, 6-8, 11, 12, 15, 16, 18-23, 26-28, 31, 32, 35, 36, and 38-40 are rejected under 35 USC 102(b) as being anticipated by Kergueris et al (Physical Review B Vol. 59, No. 19, 15 May 1999, pp. 12505-12513).

Kergueris et al disclose electron transport through a metal-molecule-metal junction. Switching between different kinds of I-V curves purportedly could be induced by varying the distance between the two metallic electrodes.

Applicants' independent Claim 1 is directed to an electric field activated molecular switch comprising a molecular system that has an electric field induced non-redox type of band gap change resulting from an intramolecular change in conjugation as p, π -electrons of the molecular system, through its highest occupied molecular orbital (HOMO) and lowest unoccupied molecular orbital (LUMO), are alternately localized and delocalized over the entire molecular system by an applied electric field. The electric field induced band gap change occurs via one of the following mechanisms: (1) molecular conformation change or an isomerization; (2) change of extended conjugation via chemical bonding change to change the band gap; or (3) molecular folding or stretching. The non-redox type of band gap change results from an intramolecular conformational change in conjugation, and does not involve an oxidation-reduction reaction.

Dependent Claims 2, 3, 6-8, 11, 12, 15, 16, and 18-20 depend from Claim 1.

Independent Claim 21 recites a method of electrically switching between two different states in the electric field activated molecular switch. The method comprises applying a voltage to a pair of wires to cause a change in the state of the molecular system at the junction thereof.

Dependent Claims 22, 23, 26-28, 31, 32, 35, 36, and 38-40 depend from Claim 21.

The Examiner argues that Kergueris et al disclose a molecular switch, citing p. 12506, Figure 1, and Abstract, p. 12506.

However, the only switching behavior described by Kergueris et al results from varying the distance between the two metallic electrodes; see Abstract, p. 12505 and Figure 8 and the discussion associated therewith bridging pages 12507-12508 (reduction of interelectrode spacing).

The Examiner attempts to map Applicants' claim language to the reference, but it is clear from reading the Examiner's comments that there is a confusion between the phrase "molecular electronic levels determined by charge displaced ***on the molecule*** [by gold electrode]" (emphasis added) (Examiner's comments; Kergueris et al, p. 12508) with "molecular electronic levels determined by charge displacement ***within the molecule***" (emphasis added) ("intramolecular change in conjugation").

Many molecules act as a switch between two electrodes, but their switching mechanisms can be completely different, and thus patentably distinct from each other.

There is also apparently a misunderstanding that the charge displacement process is an "intramolecular effect". As a matter of fact, Kergueris et al state that

"... its position [of molecular electronic levels] being determined by the amount of charge displaced on the molecule. **It has been shown that the formation of the Au-S bond involves a formal negative charge transfer δ^- from the metal to the molecule.**"

Page 12508, top four lines of second column (emphasis added).

This clearly indicates that the charge displaced on the molecule (negative charge transfer) from an electrode is a process between the electrode and the molecule, and is not an ***intramolecular*** effect, as recited in Applicants' independent claims.

The switching behavior of Kergueris et al is through a net charge transfer (charge displacement) from the electrode to the molecule to influence molecular electronic levels.

The switching behavior of Kergueris et al is completely different from Applicants' mechanism of a change of molecular HOMO-LUMO band gap via intramolecular conformation change. The charge transfer (charge displacement) of Kergueris et al is related to an electrochemical process, whereas Applicants' mechanism of E-field induced molecular conformation change occurs via a physical process. These two processes are totally different and thus Kergueris et al fail to disclose or even remotely suggest Applicants' invention as claimed.

Kergueris et al teach a molecular switch between two gold electrodes in which the conductivity (e.g., I-V characteristic) through the intervening molecule changes in response to the amount of charge that flows through the molecule. Kergueris et al acknowledge that the HOMO-LUMO gap of the molecule is reduced under an electric field (p. 12510 first column under Discussion), at least per DFT calculation. Kergueris does not teach a mechanism for this and suggests that the HOMO-LUMO change affects the above molecular HOMO-electrode Fermi level, which in turn determines the switch conductivity. Thus, the Kergueris et al teachings rely on a switch occurring between the molecule and its electrode in response to the field and the resultant charge flow. The Kergueris et al mechanism is thus very different from Applicants' approach in which a change in conductivity occurs via an inter-molecule change in the localization-delocalization of pi electrons in the molecule, independent of the characteristics of the electrodes. Claims 1 and 21 are amended to recite the three different mechanisms by which the molecule switches. This is a reinstatement of subject matter previously deleted. Kergueris et al fail to disclose or suggest any of these mechanisms.

Response to Advisory Action:

The Examiner contends that Applicants' argument

"concerning the difference between intramolecular or within the molecule and on the molecule is respectfully found to be not persuasive because while claim 1 recites 'intramolecular change in conjugation', this is believed to be taught by the prior art of record in that the charge [*sic*:

change] in the band gap of the molecules in the prior art of record would occur along with changes in the conjugation within the molecule. Band gap changes would involve changes in the molecular orbitals of the bonds which are induced by the electric field, whether the electron transfer originates from on the molecule or within the molecule. In addition, the motion of the electron would be expected to result in changes of the orbitals within the molecule, including changes in the extended conjugation of the molecule which is stabilized by the ability of electron transfer within the molecule.”

In his argument, the Examiner has overlooked the specific nature of Applicants’ claims, particularly the word “switch” and the rotation, folding, or tautomer mechanisms of the switch. While the bonding of molecule and electrode of the cited art alters the molecular orbital structure of the molecule and its HOMO-LUMO gap (true of every chemical reaction), whatever change occurs via the bonding is permanent. This permanent change in the HOMO-LUMO structure of the molecule-electrode bond is directed toward increasing the electrical conductivity of the bond. The cited art does not teach the **switching** of the HOMO-LUMO gap, nor equally as important, switching the HOMO-LUMO gap via an electric field induced change in molecule pi-electron conjugation via a rotation, folding or tautomer change in the molecule. A “switch” has two states; the cited art does not teach the switching between two pi-electron conjugation / HOMO-LUMO states as is taught and claimed in the present invention. Nor does the cited art even remotely suggest such switching.

The Examiner next contends that Applicants’ argument

“concerning the lack of change in conformation, claim 1 recites in the alternative the change in conjugation, which would be satisfied by the conjugated molecules taught by the prior art, as stated in the final rejection.”

Again, the Examiner has omitted the “switch” aspect of the present invention in comparing with the cited art. Any change in molecular conjugation occurring via the bonding reaction of the cited art is permanent and occurs prior to any application of an electric field. A permanent conformation change directed toward increased, fixed molecule-electrode conductivity is not the same as a switchable molecular conformation change that provides electrical operation between two electrically different switch states.

The Examiner notes that Applicants have pointed out that there is a charge transfer from the metal to the molecule in the prior art, but nevertheless, he continues to contend that the prior art is believed to still satisfy the recitation of intramolecular change in conjugation and change in extended conjugation, and he concludes that "it is believed that the interaction is an intramolecular effect".

In response thereto, Applicants urge that the Examiner has failed to recognize that the (permanent) change in conjugation and extended conjugation that may occur within the teachings of the prior art is *intermolecular* (not *intramolecular*). The change occurs across a molecule-electrode boundary, including changes in conjugation in the electrode interface and molecule, not just within the single molecule alone. Again, the Examiner has given this argument by ignoring the whole of Claim 1, which specifically defines Applicants' invention in terms of a "switch" and rotation, folding or tautomer conformation change, which the cited art does not teach at all.

Finally, the Examiner states that Applicants' arguments seem to be primarily concerning the mechanism of the process and the difference between within the molecule and on the molecule. The Examiner contends, however, that "the prior art of record satisfies the recitation of intramolecular and change in extended conjugation for the reasons argued above and in the final rejection".

No added response for this argument is needed in light of the above responses.

Reconsideration of the rejection of Claims 1-3, 6-8, 11, 12, 15, 16, 18-23, 26-28, 31, 32, 35, 36, and 38-40, as amended, under 35 USC 102(b) as being anticipated by Kergueris et al is respectfully requested.

Claims 1-3, 6-8, 11, 12, 15, 16, 18-23, 26-28, 31, 32, 35, 36, and 38-40 are rejected under 35 USC 102(b) as being unpatentable by McCreery (U.S. Patent Publication 2004/0190429 A1).

McCreery discloses a pixel array, including a chemical monolayer construction that comprises: (a) a substrate having a contact surface; and (b) a plurality of substantially parallel molecular units, wherein the molecular units are attached to the substrate so as to be strongly coupled electronically to the substrate, such as through a conjugated bond.

The rejected claims are discussed above.

It appears that the Examiner has confused the McCreery teaching of electron delocalization with Applicants' invention. McCreery teaches a delocalization of electrons across the molecule-electrode boundary by covalently attaching pi-electron-rich components of the molecule to the electrodes. The idea of McCreery is to obtain a fully conductive junction, that is, the metal and molecule electrons are delocalized across the junction, which is a fixed state. This is different than obtaining a switching function, as in Applicants' invention, wherein the pi-electrons of the molecule are interchangeably localized and delocalized within the molecule to induce a switch, which is a reversible changed state.

The Examiner also has apparently confused the McCreery teaching of electrons transitioning from a HOMO to LUMO energy level to force conductivity (McCreery, paragraph 0040) and selection of different molecules having different (static) HOMO-LUMO gaps from the others (McCreery, paragraph 0046) with Applicants' change in the HOMO-LUMO character of a given molecule in making it a switch. McCreery does not teach a change in the molecule HOMO-LUMO band gap. Since McCreery does not teach each of the claimed elements of Applicants' independent claims, then the claims must be deemed patentable thereover. Further, McCreery utterly fails to disclose any of the mechanisms of the electric field induced band gap change.

McCreery's patent is directed to a technology he developed by attaching monolayer molecules to an electrically conducting substrate through a conjugated bond to increase the electrical coupling between the electrode and the molecule (see the Abstract and paragraphs 0014-0015). His switching mechanism is based on injecting electrons (from the electrode) into the LUMO of the chemical monolayer (to make it act as Schmidt trigger device; see, paragraph 0108). He also suggests other mechanisms, such as using electromagnetic radiation to change the property of at least some of the molecular units (paragraphs 0039-0040 and claims 1 and 3). Apart from those mechanisms, McCreery never discloses or suggests anything to alter the molecular band gap with an E-field induced intramolecular conformation change. Even though McCreery mentions that there might be other mechanisms that exist (paragraph 0040), he does not give any clue on what those other mechanisms might be.

Further, McCreery never discloses how to use an electric field to change molecular orbital levels, and never even remotely suggests how to achieve any molecular conformation change. Additionally, molecular orbitals can be altered by many means, such as redox, metal chelation, polarization, tautomerization or conformation change, etc. All such alterations do not disclose or suggest Applicants' claimed alterations of molecular levels. And a change of molecular orbital levels does not necessarily reflect a change in molecular conformation. The Examiner's statement that "[t]he delocalization [*sic: delocalization*] of the molecular orbitals and the change in the electron energy levels is a mechanism of change in the molecular orbital conformations" is not supported by McCreery.

Finally, a change in electron energy levels can be accomplished by many means, just as mentioned earlier, such as redox reaction, metal chelation, polarization, tautomerization or conformation change, etc. An increase in the delocalization of molecular orbitals is one such way to change electron energy levels. However, a change of delocalization of molecular orbitals can be accomplished permanently or temporarily. McCreery's way is to connect an aromatic molecule to the electrode through a conjugated unit, to achieve increased delocalization of electrons over both the monolayer and the electrical substrate (paragraph 0015). This is a permanent increase of the delocalization. In direct contrast, Applicants employ an electric field to manipulate the molecular conformation change to achieve a temporary change of the pi-electron delocalization. That is total different than what McCreery teaches.

Summarizing, the key issue here is that McCreery does not teach a method to controllably change the HOMO-LUMO gap of the molecule via an electric field induced and reversible localization and delocalization of pi-electrons. What McCreery teaches is a method to permanently delocalize pi-electrons at the molecule-electrode interface, thereby allowing better electrical coupling between the two.

Response to Advisory Action:

The arguments made above under "Response to Advisory Action" with regard to Kergueris et al obtain here as well.

Reconsideration of the rejection of Claims 1-3, 6-8, 11, 12, 15, 16, 18-23, 26-28, 31, 32, 35, 36, and 38-40, as amended, under 35 USC 102(b) as being unpatentable by McCreery is respectfully requested.

Claims 1-3, 6-8, 11, 12, 15, 16, 18-23, 26-28, 31, 32, 35, 36, and 38-40 are rejected under 35 USC 103a as being unpatentable over Zhou et al (Appl. Phys. Lett. 71(5), 4 Aug. 1997, pp. 611-613).

Zhou et al disclose nanoscale metal/self-assembled monolayer/metal heterostructures, specifically, diodes.

The rejected claims are discussed above.

The Examiner essentially argues that all the features of Applicants' invention are shown, but for a switch, which the Examiner contends is obvious in view of the disclosure by Zhou et al that the molecule has rectifier properties.

The Zhou article describes a method and chemistry for producing molecular wires across electrode junctions. The wires were found to have a rectifying function. The Examiner claims that the Zhou art could be easily extended beyond rectification to switching by one skilled in the art because the molecule is conjugated, electrons hop along the molecule and somehow this changes the molecular orbitals of the molecule in such a way that creates a switch.

There is nothing implied or obvious within the teachings of Zhou that could possibly be extended to the teachings of a switch. It is well known in the art that conjugated molecules have electrical conductivity. This is taught, for example, by each of the other two cited references. The rectification function of Zhou lies in the molecule-electrode junctions, not inherently in the molecule itself. Even assuming *arguendo* that this rectification function does provide an obvious extension to the switch (which it does not), then the switch would be integral to the molecule-electrode junction. The switch of Applicants' invention is totally confined to mechanisms fully embodied within the molecule alone. That is, it is the molecule that is doing the switching, not the molecule plus electrode. The independent claims each recite "an **intramolecular** change in conjugation" (emphasis added). Further, Zhou et al are totally silent on the three claimed mechanisms of an electric field induced band gap change.

Response to Advisory Action:

The arguments made above under "Response to Advisory Action" with regard to Kergueris et al obtain here as well.

Reconsideration of the rejection of Claims 1-3, 6-8, 11, 12, 15, 16, 18-23, 26-28, 31, 32, 35, 36, and 38-40, as amended, under 35 USC 103a as being unpatentable over Zhou et al

Although the Examiner does not specifically refer to allowable claims, it appears from the Office Action Summary that Claims 4, 5, 9, 10, 13, 14, 17, 24, 25, 29, 30, 33, 34, and 37 would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims. However, based on the foregoing arguments, Applicants assert that the remaining claims are also allowable.

The foregoing amendments and arguments are submitted to place the application in condition for allowance. The Examiner is respectfully requested to take such action. If the Examiner has any questions, the Examiner is invited to contact the undersigned at the below-listed telephone number. HOWEVER, ALL WRITTEN COMMUNICATIONS SHOULD CONTINUE TO BE DIRECTED TO: IP ADMINISTRATION, LEGAL DEPARTMENT, M/S 35, HEWLETT-PACKARD COMPANY, P.O. BOX 272400, FORT COLLINS, CO 80527-2400.

Respectfully submitted,

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